



A Scoping Review of the Use of Indigenous Food Sovereignty Principles for Intervention and Future Directions

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ABSTRACT

Indigenous food sovereignty (IFS) represents a community-led movement with potential to reduce health inequities, but no scoping review of the impact of taking an IFS approach on intervention research has been conducted. This review sought to: 1) describe intervention studies that employ IFS principles, and 2) describe the impact of studies using IFS principles on food access, eating patterns, diet quality, physical activity, and health. Through a literature review, 4 IFS principles were identified: 1) community ownership, 2) inclusion of traditional food knowledge, 3) inclusion and promotion of cultural foods, and 4) environmental/intervention sustainability. Twenty intervention studies published between January 1, 2000 and February 5, 2020 were included. Most of the studies that scored high in IFS principles saw a positive impact on diet. This review found evidence supporting the value of IFS principles in the development, implementation, and evaluation of health interventions for Indigenous communities. *Curr Dev Nutr* 2021;5:nzab093.

Keywords: indigenous food systems, Native American, cultural food system, traditional knowledge, indigenous peoples, interventions, food access, indigenous food sovereignty, obesity, diabetes

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Abbreviations used: CBPR, community-based participatory research; IFS, indigenous food sovereignty; IRB, institutional review board; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT, randomized control trial.

Introduction

Food sovereignty was defined by the first global Forum for Food Sovereignty as “the right of peoples to healthy, culturally appropriate food produced through ecologically sound and sustainable methods, and their right to define their own food and agriculture systems”⁽¹⁾. More specifically, Indigenous Food Sovereignty (IFS) shares some of these principles but generally moves beyond just food access to incorporate complex relations between Indigenous peoples, the land, and sacred food knowledge^(2–6). IFS can be defined as a rights-based approach to land, food, and the ability to control a production system that emphasizes accountability to holding culturally, ecologically, and spiritually respectful relations (with plants, animals, environment, and surrounding communities) within those systems^(7, 8). Common guiding principles of IFS may be summarized as: 1) community ownership, 2) inclusion of cultural food knowledge, 3) promotion of traditional and local foods, and 4) environmental changes to promote access to land, food, and maintain intervention sustainability^(8–10). In the United States and Canada Indigenous peoples experience disproportionately

high rates of type 2 diabetes, obesity, and food insecurity^(11–18). These important health inequities rooted, in large part, in dietary disparities⁽¹⁹⁾, highlight the need for interventions and programs that promote access to, and consumption of, traditional and culturally appropriate healthy foods among Indigenous peoples. IFS is an important way in which communities are able to improve access to healthy, culturally appropriate foods and diet quality, while facilitating cultural connections, and ultimately improving community wellness.

In recent years, intervention studies that aim to address inequities in health, nutrition, and food security among Indigenous Nations or communities have explicitly or implicitly employed some of the guiding principles of food sovereignty to design, implement, and/or evaluate their interventions. However, to our knowledge, no reviews have systematically assessed how IFS principles have been applied to the development, implementation, and evaluation of interventions or what has been their impact on health-related outcomes^(20, 21). The primary goals of this study were to systematically review evidence regarding: 1) the level of application of IFS principles in the design, implementation, and evaluation of nutrition and food interventions; 2) how these

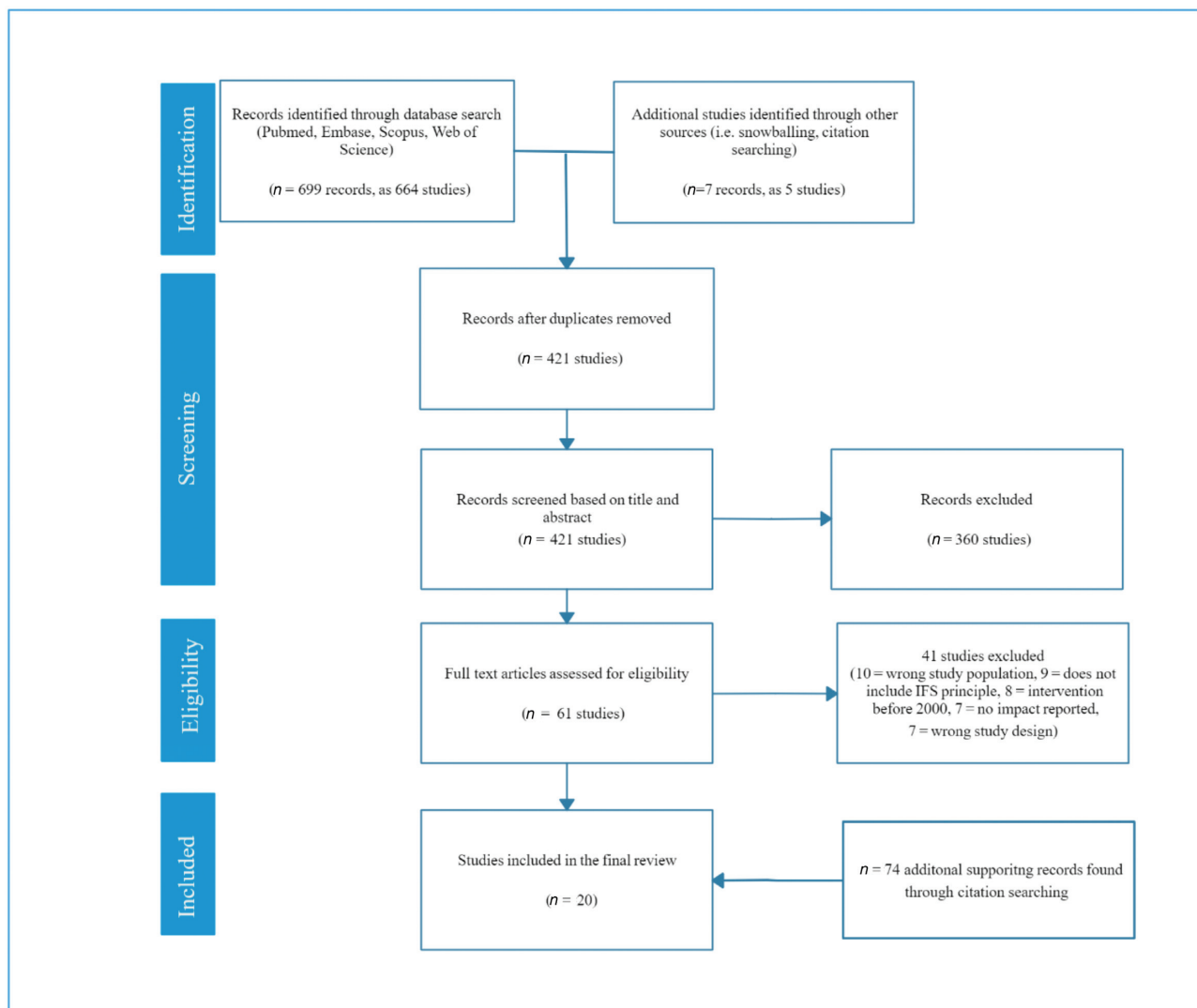


FIGURE 1 Flow chart of decision process for inclusion and exclusion of studies in the Indigenous Food Sovereignty scoping review

interventions impacted food access, healthy eating, diet quality, physical activity, and health outcomes; and 3) what are the gaps in current research and priorities going forward.

Methods

This study undertook a scoping literature review of published gray and peer-reviewed literature regarding intervention studies that aimed to impact food and nutrition outcomes in Indigenous communities in North America (the United States and Canada). This scoping review intended to clarify key concepts and definitions of IFS for intervention research and examine how research interventions that use principles of IFS are conducted, goals that are well aligned with the purposes of a scoping review (22).

Search and sampling strategy

Two researchers (TLM, UC-R) searched for food, nutrition, or food system intervention trials that reported on psychosocial, food access,

behavioral, or health outcomes among Indigenous Nations and Indigenous communities in North America. In consultation with a Johns Hopkins Welch Medical Library informationist, the searches were conducted using PubMed (Medline), Embase, Scopus, and Web of Science to identify peer-reviewed articles using the following search strategy: [(“American Indian*” OR “Native American*” OR “Alaska Native*” OR “Indigenous People*” OR “First Nation*” OR “North American Indian*”) AND (“Food” OR “Nutrition” OR “Cultural Food*” OR “Traditional Food*”) AND (“Intervention”)]. The search strategy followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for the reporting of systematic reviews (23). **Figure 1** presents the PRISMA flow diagram demonstrating the selection process for article/study inclusion.

Trial selection criteria and process

The titles and abstracts of studies pertaining to interventions were searched to identify if articles met the following inclusion criteria.

Inclusion criteria.

The following inclusion criteria were used for each potential trial study: 1) reported in the English language; 2) >50% of the study population included Indigenous Nations or Indigenous communities either in the United States or in Canada; 3) presented impact findings of intervention or program designed to improve nutritional status (i.e., undernutrition, overnutrition, breastfeeding), diet-related health status, or direct underlying determinants of nutritional status (i.e., dietary intake, food security, psychosocial factors, food access, other behavioral outcomes); 4) the intervention occurred after the year 2000 and was published between January 1, 2000 and February 5, 2020; and 5) included ≥ 1 core IFS principles at a level of 1.5 or higher. These inclusion criteria were carefully chosen to aid in selecting interventions that represent the state of food and nutrition research in Indigenous communities over the past 20 years. To provide a more detailed review of the application of food sovereignty principles to intervention research, included interventions required a minimal demonstration (score of 1.5) of ≥ 1 principle of food sovereignty.

Exclusion criteria.

Trials were excluded if: 1) there was no published information about their impact on diet-related health, nutritional status, or underlying determinants of nutritional status as specified above; 2) they focused on diet-related chronic disease or infectious disease but did not intervene on diet, nutrition, or food; or 3) they did not include ≥ 1 core principles of IFS at a score of 1.5.

Study selection and screening processes.

After titles and abstracts were independently screened by the 2 reviewers (TLM and UC-R), any discrepancies were resolved by an adjudicator (JG). Then each primary reviewer (TLM, UC-R) independently examined if the full-text met the inclusion criteria using the Covidence systematic review tool (24). Disagreements regarding eligibility of studies were resolved by discussion and consensus. Of the 420 studies considered during the title and abstract review, 360 were excluded. Of the 60 remaining studies for full-text screening, 40 were excluded, leaving a final sample of 20 studies.

When the researchers agreed that a trial study fit the selection criteria, they then searched for additional relevant documents about the trial (i.e., community reports, news articles, etc.) using PubMed, Google Scholar, and Google. The references of relevant articles were also reviewed to identify any additional articles of interest.

IFS scoring system.

Consistent with the guiding principles of IFS previously discussed (2, 8–10), a 4-part definition was used in the assessment of IFS in this review (Table 1): 1) community ownership, 2) inclusion of traditional food knowledge, 3) inclusion and promotion of cultural and traditional foods, and 4) environmental and intervention sustainability. This scoring system was created to operationalize the application of IFS principles to intervention research and has potential to be used in other evaluations of intervention research in Indigenous communities. Table 1 was used to score interventions for each principle, as well as to provide an overall IFS score for each intervention. Each principle was scored as high, medium, low, or none (3, 2, 1, and 0, respectively). Detailed de-

scriptions of criteria for meeting each level of IFS scores can be found in Table 1.

The first principle in the context of research interventions relates to the degree to which the community is involved in the intervention. In line with community-based participatory research (CBPR) principles ideally, the community is involved in the initiation, development, implementation, and sustainability efforts of an intervention (25). The second principle relates to the degree to which traditional food knowledge is emphasized as part of the intervention. This includes generational knowledge passed down from Elders and other knowledge keepers, storytelling, and honoring Indigenous ways of planting, cultivating, harvesting, processing, and preparing indigenous foods. The third principle relates to how traditional and cultural foods are included in the intervention. Traditional and cultural foods are important to the identities of many Indigenous peoples. Additionally, traditional foods are nutrient dense and can be supportive of a healthy diet. Promoting traditional and cultural foods can be important for ensuring that the foods promoted through the intervention are relevant and culturally acceptable to the communities engaged in the intervention. Further, promoting cultural and traditional foods has potential to garner further demand for foods produced by grassroots food sovereignty movements. The second and third principles are closely related but differ in that an intervention can promote consumption of traditional foods (principle 3) without acknowledging the relationality and traditional knowledge associated with growing, harvesting, and preparing these foods (principle 2). The fourth principle relates to the ecological responsibility of Indigenous peoples to grow and process foods in an environmentally responsible way, as well as the responsibility of the researchers to conduct research in a sustainable way. Interventions representing this principle promote sustainable change to food systems and build community capacity to continue implementing activities that support IFS principles after the intervention is complete.

Data extraction and analysis

The 2 primary reviewers (TLM, UC-R) independently reviewed full-text articles and any relevant documents from the gray literature for each trial study and extracted data using standardized data abstraction tables. These tables included the author and year in which the study was published, the name of the tribe/community (if provided) and state/country, institutional review board (IRB) or tribal approvals, study topic, study design, theory or behavior change framework used (if applicable), study goal, study sample, description of the intervention, process evaluation information, how it was evaluated, impacts at different levels, and the level of agreement with each of the 4 principles of IFS (high = 3, medium = 2, low = 1, none = 0), and overall agreement with IFS based on a 12-point scale (3 points possible for each of the 4 characteristics). Finally, a third reviewer (JG) resolved any discrepancies between the 2 primary reviewers, compared scores for each trial study, and provided an average score for each study trial for each of the 4 IFS principles.

Results**IFS principle scores**

Among IFS components, ownership ranked highest (2.0), followed by knowledge (1.8), environment (1.4), and traditional foods (1.3). The

TABLE 1 Principles of indigenous food sovereignty, with scoring criteria¹

IFS principle	0: None	1: Low	2: Medium	3: High
Principle 1: community ownership	No evidence that any level of community ownership was part of the trial design/implementation	Mention little evidence of community involvement, or community involvement/consultation only in planning and/or dissemination	Offers evidence that community involved in planning and implementation of intervention	Community involved in every aspect of the project—planning, implementation, evaluation, dissemination (ongoing engagement)
Principle 2: inclusion of cultural knowledge	No evidence of cultural appropriateness/adaptation/relevance in the intervention strategies (indicators: no FR of any kind; imposition of existing approaches and strategies on new communities)	Minor evidence of cultural appropriateness/adaptation/relevance in intervention strategies [indicators: minor FR (e.g., a few focus groups only, adaptation of existing materials from other settings)]	Moderate evidence of cultural appropriateness/adaptation/relevance in the intervention strategies [indicators: substantial multistage FR, iterative adaptation with community feedback using multiple methods; some use of cultural food knowledge (concepts, categories), some use of local communication channels; limited creation of new approaches and strategies for a specific community]	High evidence of cultural appropriateness/adaptation/relevance in the intervention strategies (indicators: substantial multistage FR, intervention demonstrates substantial community-specific cultural food knowledge, cultural nutrition education, stories; heavy use of appropriate local communication channels; strong evidence of creation of new approaches and strategies for specific communities)
Principle 3: inclusion of traditional foods	No evidence of inclusion of local/traditional and healthy foods in the intervention	Intervention promotes healthy foods, but not local/traditional or intervention says it promotes traditional foods but limited description of the traditional foods or promotion efforts in a limited manner (e.g., lip service)	Heavily promotes healthy local/traditional foods via multiple approaches as part of an intervention	Promotion of traditional foods is the central focus of the intervention
Principle 4: environmental sustainability of intervention	No mention of efforts to make intervention sustainable or policy implications required to reconcile indigenous food practices with dominant society economic practices	Briefly mentions sustainability efforts or policy implications for interventions, but does not offer specific action plan and/or does not mention land rights or land connections	Significant detailed description of intervention sustainability, policy implications along with some recommendations and/or food sustainability, but some mention (activities with land) of connection to land or land rights	Central focus on intervention sustainability, impact and importance of traditional foods on local environment, or policy changes to sustain or implement healthy environment changes

¹FR, formative research; IFS, indigenous food sovereignty.

third reviewer then added these scores together to create an overall IFS score. These scores are intended to provide an indication of the degree to which an intervention is providing supporting for food sovereignty in the community (or communities) they are working with. Overall IFS scores ranged from 3 to 11.5, with a mean of 6.6. Based on these scores, we categorized studies into high (>7), medium (6, 7),

and low (<6). The IFS scores for each intervention are presented in [Table 2A–C](#).

Description of studies

[Tables 3](#) and [4](#) present the description of the studies' populations, objectives, theoretical frameworks ([Table 3A–C](#)) and study design,

TABLE 2A IFS principles score, overall IFS score¹

Project name	Healthy Children Strong Families 1	Nega Elicarvigmun (Fish to School)	Healthy Foods North	Iron Deficiency Anemia Infants	THRIVE	Healthy Children Strong Families 2	Medicine Wheel children
IFS1: Ownership	3	2.5	2.5	3	3	3	1.5
IFS2: Knowledge	3	3	2.5	2.5	2	2	2.5
IFS3: Traditional Foods	3	3	2.5	3	1.5	2	2.5
IFS4: Environment	2.5	2.5	2.5	1.5	2	1.5	1
IFS score	11.5	11	10	10	8.5	8.5	7.5

¹IFS, indigenous food sovereignty; THRIVE, Tribal Health and Resilience in Vulnerable Environments.

intervention descriptions, and process evaluation data (Table 4A–C) organized by IFS score category.

Study location.

Of the studies reviewed, the majority were conducted in the United States (17/20 in the United States; 3/20 in Canada). Of the US studies, 2/17 were conducted in Alaska and 4/17 were conducted in the South-west US region.

Behavior change framework.

All 20 studies reviewed reported using a theoretical framework, with the most common being social cognitive theory (13/20), followed by stages of change (4/20), and the social ecological model (3/20); many studies (9/20) combined multiple frameworks.

Study goal.

The stated objectives of the studies were varied: 8/20 studies targeted weight gain or obesity; 7/20 aimed at changing a dietary outcome, and 5/20 mentioned diabetes or another health outcome as its ultimate objective.

Study design.

Half of the studies (10/20) used a randomized control trial (RCT) study design. Studies that scored high in IFS were more likely (5/7) to use an RCT study design than those with medium (5/8) or low scores (1/5).

Study sample.

Evaluation sample sizes in terms of the number of individuals ranged greatly, from 22 (Generations Health) to 3135 (Diabetes Prevention Program Demonstration Project), with a mean of 464. Roughly half the

studies focused on adults (11/20), whereas the remainder targeted children and adolescents. Studies that scored high in IFS tended to be conducted in children aged <18 y (5/7) compared with medium IFS scores (3/8) or low IFS scores (1/5).

IRB and community approvals.

All studies reported having some form of institutional (university or other public health authority) approval for research. The majority of studies (17/20) studies reported having some form of community approval. Examples of community approvals included Tribal IRBs, Tribal Council approvals, and community partner approvals.

Intervention strategies.

Interventions took place in many different venues, with the most common strategies being food stores (7/20) and group counseling in community settings (e.g., clinics) (6/20) (Table 4A–C). Other common intervention modes included the use of community media (e.g., radio, newspapers, and posters) (7/20), schools (4/20), and home-based activities, including mailings, written assignments, and home visits (6/20). Smaller numbers of trials included community events (3/20), use of social media (2/20), and intervening at worksites (1/20). Most trials used multiple strategies.

Intervention activities supporting IFS by principle.

The first principle, community ownership, was demonstrated in studies through their use of a CBPR approach and specific mentions of how the intervention was guided or led by community. Examples of intervention activities that supported community ownership included: creation or use of community research councils (or community advisory boards); involving Elders and community leaders in intervention design, implementation, and evaluation; and prioritizing community dissemination

TABLE 2B IFS principles score, overall IFS score¹

Project name	Apache Healthy Stores	Medicine Wheel Adults	Navajo Healthy Stores	Earthbox	OPREVENT	Traditions of the Heart	Generations Health	Journey to Native Youth Health
IFS1: Ownership	2	1.5	2.5	2	1.5	1.5	1	2.5
IFS2: Knowledge	1	2	1	1	2	2.5	2	2
IFS3: Traditional Foods	1.5	2.5	1	1.5	1	2	2	0.5
IFS4: Environment	2.5	1	2.5	2	2	0.5	1	1
IFS score	7	7	7	6.5	6.5	6.5	6	6

¹IFS, indigenous food sovereignty; OPREVENT, Obesity Prevention and Evaluation of InterVention Effectiveness in NaTive North Americans.

TABLE 2C IFS principle scores, overall IFS score¹

Project name	Together on Diabetes	Diabetes Prevention Demo Project (Special Diabetes Program)	Strong in Body and Spirit (Urban DPP)	Healthy Food Labels	Native American Weight Loss Movement
IFS1: Ownership	2.5	1.5	1	1.5	2
IFS2: Knowledge	1.5	1	1.5	1.5	1
IFS3: Traditional Foods	0	1	0	0	0
IFS4: Environment	1.5	0	1	0	0
IFS score	5.5	3.5	3.5	3	3

¹DPP, diabetes prevention program; IFS, indigenous food sovereignty.

through community reports and other multimedia materials (including YouTube videos).

The second principle, cultural food knowledge, was supported through intervention activities that were tribally or regionally specific and included activities such as: berry picking, gardening, harvesting, and cooking lessons/demonstrations. These activities promote the transmission of cultural food and nutrition knowledge throughout the community and support intergenerational food system resilience.

The third principle, promotion and inclusion of traditional foods, was demonstrated in interventions through specific promotion of tribally and culturally specific traditional foods and made explicit the connection between cultural values and traditional foods. One intervention, Fish to School, promoted access to and consumption of fish (a traditional food) as the primary intervention goal.

The final IFS principle, environmental sustainability, was supported through the planning of sustainable intervention activities, as well as activities that supported cultural connections to land and water. Whereas the activities that supported this principle varied by intervention topic, the interventions that scored highly on this principle tended to focus on addressing environmental barriers to healthy food access through creation of community gardens, food distribution programs, or other similar mechanisms to sustainably improve access to healthy foods.

Process evaluation.

Some form of process evaluation was reportedly conducted in just over half of the studies (11/20), but in 2 cases these results were not reported.

Outcome assessment methods and impact.

Table 5A–C presents assessment and impact for the following outcomes: food environment/policy, diet and food intake/acquisition, physical activity/sedentary behaviors, psychosocial factors, and health.

Food environment/policy assessment and impact.

Only 7/20 studies reported an assessment of the food environment (such as availability of healthy foods in stores), but of those, almost half (3/7) did not report the actual outcome of the intervention on the food environment.

Diet/food intake or acquisition impact.

Various methods were used to assess dietary outcomes or food consumption: 10/20 studies used dietary screeners; and 8/20 studies used multiple 24-h dietary recalls or FFQs that were either adapted for the population targeted or created specifically for the target population. The

majority (5/7) of studies that scored high in IFS used screeners or an FFQ (that had not been adapted to the population) to assess dietary outcomes. The majority of the studies that scored high on IFS (5/7) observed a positive impact on dietary intake (e.g., diet quality) based on the intervention, compared with 3/7 studies that assessed diet in those studies with medium IFS scores. Although the majority of studies that scored low on IFS and assessed diet (4/5) also reported an impact on diet, only 1 of these studies had an RCT design.

Physical activity/sedentary behaviors assessment and impact.

The majority of the studies assessed physical activity and sedentary behavior or screen time activity (12/20) with a variety of tools (accelerometers, surveys, diaries, or recalls), but only 11/12 studies reported whether or not there was an impact. Of those, 6/12 studies reported an improvement in physical activity, with an additional study reporting effects on adults, but no impact on children. Nonetheless, only 2 of those studies had an RCT design or a control design.

Psychosocial factors assessment and impact.

The majority of studies included psychosocial factors (15/20); 5/15 included self-efficacy, and the others included constructs such as knowledge, perceptions, preferences, intentions, and social support.

Health outcomes assessment and impact.

Health outcomes—defined as anthropometric measures or other indicators of chronic disease (anthropometry, biomarkers, self-reported disease)—were assessed in the majority of studies (13/20). Of the studies that assessed some form of health outcome, 8/13 found ≥ 1 positive impact, whereas 5/13 did not. The majority of the studies that found health impacts were in the low-scoring IFS studies (4/5 studies assessed health outcomes and showed some benefits in health outcomes including weight, hypertension, and fasting blood glucose). Most of the studies that scored high in IFS did not assess health impacts but assessed dietary intake and food environments (4/7).

Discussion

This scoping review sought to operationalize IFS principles to evaluate interventions and the impact of these interventions. This article is, to the best of our knowledge, the first attempt to develop principles of IFS to aid the systematic evaluation of IFS interventions, based on the previous conceptualizations and definitions of IFS. After developing the 4

TABLE 3A Study goals and overall IFS score (high scores 7.5–11.5)¹

Project name	Mega					Healthy Children Strong Families 1	Elicarvigmun (Fish to School)	Healthy Foods North	Iron Deficiency Anemia Infants	THRIVE	Healthy Children Strong Families 2	Medicine Wheel Children
	Published: (26–31)	Published: (32–35)	Published: (36–38)	Published: (39–46)	Published: (47)							
Data sources	4 AI tribes (Menominee, Lac du Flambeau, Bad River, and Oneida); Wisconsin	Yup'ik peoples; SW Alaska	Inuit, Inuvialuit communities; Canadian Arctic	James Bay Cree; Northern Quebec	Chickasaw and Choctaw Nations; Oklahoma	Chickasaw and Choctaw Nations; Oklahoma	Chickasaw and Choctaw Nations; Oklahoma	Chickasaw and Choctaw Nations; Oklahoma	Chickasaw and Choctaw Nations; Oklahoma	Chickasaw and Choctaw Nations; Oklahoma	Chickasaw and Choctaw Nations; Oklahoma	Chickasaw and Choctaw Nations; Oklahoma
IRB/tribal and community approvals	University of Wisconsin-Madison's Health Sciences IRB; and approval was obtained from each tribal council and Head Start Program	University of Alaska Fairbanks; and Human Subjects Committee at the Yukon Kuskokwim Health Corporation	Committee on Human Studies at the University of Hawaii; Office of Human Research Ethics at the University of North Carolina at Chapel Hill; Beaufort Delta Health and Social Services Authority Ethics Review Committee; and Nunavut Research Institute and the Aurora Research Institute	Ethical Review Committee at McGill University	University of Oklahoma Health Sciences Center IRB; Chickasaw Nation IRB; and Choctaw Nation of Oklahoma IRB	University of Oklahoma Health Sciences Center IRB; Chickasaw Nation IRB; and Choctaw Nation of Oklahoma IRB	University of Oklahoma Health Sciences Center IRB; Chickasaw Nation IRB; and Choctaw Nation of Oklahoma IRB	University of Oklahoma Health Sciences Center IRB; Chickasaw Nation IRB; and Choctaw Nation of Oklahoma IRB	University of Wisconsin Health Sciences IRB; 1 site approved through their own IRB	University of Wisconsin Health Sciences IRB; 1 site approved through their own IRB	University of Wisconsin Health Sciences IRB; 1 site approved through their own IRB	South Dakota State IRB
Model	Social cognitive theory, family systems theory	Social cognitive theory	Social cognitive theory, stages of change	Social marketing theory	Social cognitive theory	Social cognitive theory	Social cognitive theory, stages of change	Social marketing theory	Social cognitive theory	Social cognitive theory; family systems theory	Social cognitive theory; family systems theory	Medicine Wheel model
Study goals	To reduce overweight in young children through a home visit intervention	To improve diet, fish intake, and psychosocial factors regarding traditional foods	To address nutrition transition using culturally sensitive approaches (e.g., increase traditional food consumption)	To promote knowledge and behaviors to reduce IDA in infants	To improve the food environment by designing, implementing, and evaluating a food store intervention	To improve the food environment by designing, implementing, and evaluating a food store intervention	To address nutrition transition using culturally sensitive approaches (e.g., increase traditional food consumption)	To promote knowledge and behaviors to reduce IDA in infants	To improve the food environment by designing, implementing, and evaluating a food store intervention	To determine if a mailed home-based healthy lifestyle intervention can reduce child overweight	To determine if a mailed home-based healthy lifestyle intervention can reduce child overweight	To determine if culturally relevant knowledge improves child FV intake
IFS score	11.5	11	10	10	8.5	8.5	10	10	8.5	8.5	8.5	7.5

¹ AI, American Indian; FV, fruit and vegetable; IDA, iron deficiency anemia; IFS, indigenous food sovereignty; IRB, institutional review board; NA, Native American; SW, southwest; THRIVE, Tribal Health and Resilience in Vulnerable Environments.

TABLE 3B Study goals overall IFS score (medium scores 6–7)¹

Project name	Apache Healthy Stores	Medicine Wheel Adults	Navajo Healthy Stores	Earthbox	OPREVENT	Traditions of the Heart	Generations Health	Journey to Native Youth Health
Data sources	Published: (66–70) Other: (71)	Published: (64, 72)	Published: (68, 73, 74) Other: (71, 75, 76)	Published: (77, 78) Other: (79)	Published: (80–87) Other: (88)	Published: (89–93) Other: (94)	Published: (95)	Published: (96–98)
Name of tribe/region	White Mountain Apache and San Carlos Apache; Arizona	Cheyenne River Sioux; South Dakota	Navajo Nation; New Mexico	First Nations Reserve; Alberta, Canada	2 Navajo communities, Okhay Owingeh, Keweenaw Bay Indian Community, Hannahville Potawatami; Michigan and New Mexico	Alaskan Natives; Anchorage, AK	NA reservation; Northern Plains	Two NA reservations; Montana
IRB/tribal and community approvals	Johns Hopkins Bloomberg School of Public Health Committee on Human Research; and San Carlos and White Mountain Apache tribal approval	Aberdeen Area Indian Health Services IRB; South Dakota State University IRB; and Cheyenne River Sioux Tribal Council Health Committee	Johns Hopkins IRB; and Navajo Nations Human Research Review Board	University of Alberta ethics review board; and research steering committee for the study composed of researchers, community Elders, educators, health workers, and individuals from community departments	Johns Hopkins IRB; Indian Health Service IRB; and Navajo Nation Human Research Review Board	Alaska Area and the Centers for Disease Control and Prevention IRB; and Southcentral Foundation Board of Directors Tribal Approval	Salish-Kootenai College IRB	University of Montana IRB; tribal councils and health committees; and local community advisory boards
Model	Social cognitive theory, theory of planned behavior	Medicine Wheel model	social cognitive theory, theory of planned behavior	Social cognitive theory	Social cognitive ecological model	Stages of change	Ecological model of physical activity	Transtheoretical model of change
Study goals	To improve the food environment and diet in communities	To determine if culturally relevant dietary care results in improved diabetes control	To improve healthy food access and consumption and reduce risk of obesity	To improve FV consumption and preferences among children	To reduce obesity among adults	To use Native traditions/community strengths to improve diet, activity, and reduce tobacco use and stress	To assess impact of out-of-school program on child behavior and health	To modify the DPP for Native youth, leading to healthy weight and improved diet and PA
IFS score	7	7	7	6.5	6.5	6.5	6	6

¹DPP, diabetes prevention program; FV, fruit and vegetable; IFS, indigenous food sovereignty; IRB, institutional review board; NA, Native American; OPREVENT, Obesity Prevention and Evaluation of Intervention Effectiveness in NaTive North Americans; PA, physical activity.

TABLE 3C Study goals and overall IFS scores (low scores 3.5–5.5)¹

Project name	Together on Diabetes	Diabetes Prevention Demo Project (Special Diabetes Program)	Strong in Body and Spirit (Urban DPP)	Healthy Food Labels	Native American Weight Loss Movement
Data sources Name of tribe/region	Published: (99–101) 3 Navajo, 1 Apache; state(s) not specified	Published: (102–108) 80 NA tribes; 18 states	Published: (109–113) Urban settings; Southwest USA	Published: (114) Rosebud Sioux tribe; South Dakota	Published: (115) 4 NA communities (Lawrence, Kansas, Kansas City); Kansas
IRB/tribal and community approvals	Johns Hopkins IRB; Navajo Nation Human Research Review Board; White Mountain Apache Tribal Health Board and Tribal Council; Phoenix Area Indian Health Service IRB; and the local Indian Health Service and school boards	University of Colorado Anschutz Medical Center IRB; and National Indian Health Service IRB	University of New Mexico Health Sciences Center Human Research Review Committee; and regional Indian Health Service IRB	University of Nebraska-Lincoln IRB; and Rosebud Sioux tribal authorities	University of Kansas Human Subjects Committee; and tribal councils
Model	Social ecological model, social cognitive theory	Health belief model	Social cognitive theory	Behavioral economics	Stages of change, social cognitive theory
Study goals	To prevent and manage diabetes through...	To assess impact of a modified DPP lifestyle program in weight among at-risk adults	To assess effectiveness of a low-intensity diabetes prevention intervention on diet	To use behavioral economics to enhance label effectiveness in promoting healthy food choices	To modify DPP to improve weight loss
IFS score	5.5	3.5	3.5	3	3

¹DPP, diabetes prevention program; IFS, indigenous food sovereignty; IRB, institutional review board; NA, Native American.

TABLE 4A Study design, process evaluation results, and overall IFS score (high scores 7.5–11.5)¹

Project name	Nega					THRIVE	Healthy Children Strong Families 2	Medicine Wheel children
	Healthy Children Strong Families 1	Elicarvigmun (Fish to School)	Healthy Foods North	Iron Deficiency Anemia Infants	Healthy Children Strong Families 2			
Study design	RCT	Multilevel community intervention	Quasi-experimental	Pre-post, no comparison group	Cluster RCT	RCT, modified crossover	RCT	
Study sample	98 families with child, 2–5 y	76 adolescents, middle school and high school	378 adults	45 mothers of infants	8 food stores, 1637 shoppers	450 parent-child dyads, children ages 2–5 y	33 elementary school children, 3rd graders	
Intervention strategies	Home visiting by trained NA community mentors (year 1) Newsletters (year 2)	Schools: classroom lessons in 2 school districts, food service (fish served weekly) Community events	Food stores: stocking promoted foods, posters, shelf labels, interactive sessions TV/radio ads; visual materials Increased PA opportunities (walking clubs) 7-phase intervention (14 mo)	Group sessions on cooking Visual materials (posters, pamphlets, newsletters, grocery store displays) Radio dialogues	Food stores: placement of healthy foods in accessible locations, signage, pricing discounts	Home: 12-lesson mailed educational materials; social media	Schools: 6 classroom lessons	
Process evaluation	Medium	None	High	Medium	High	None	None	
Process evaluation results	Not reported	None	Not reported	Fair	Excellent	None	None	
IFS score	11.5	11	10	10	8.5	8.5	7.5	

¹IFS, indigenous food sovereignty; NA, Native American; PA, physical activity; RCT, randomized controlled trial; THRIVE, Tribal Health and Resilience in Vulnerable Environments.

TABLE 4B Study design, process evaluation results, and overall IFS score (medium scores 6–7)¹

Project name	Apache Healthy Stores	Medicine Wheel Adults	Navajo Health Stores	Earthbox	OPREVENT	Traditions of the Heart	Generations Health	Journey to Native Youth Health
Study design	Quasi-experimental, comparison areas	RCT	Group (store region) RCT	Pre-post, no comparison	Community RCT	Pre-post design	Individual RCT	RCT
Study sample	176 adult respondents	114 adults with T2DM	145 adults	76 children, grades 1–6	424 adults, 18–75 y	269 Alaska Native women	22 children (52% NA), ages 6–9 y	64 children, ages 10–14 y
Intervention strategies	Food stores: increased stocking of healthy promoted foods, visual materials (posters, shelf labels); cooking demonstrations and taste tests, educational displays Newspaper cartoons Radio announcements	Group counseling, individualized meal plans	Food stores: increase stocking healthy foods, interactive sessions, handouts, giveaways, posters, shelf labels, booklets Radio announcements	Schools: classroom garden, healthy snack program, educational curricula	Food stores: increase stocking healthy foods, posters, shelf labels, booklets, interactive sessions Home: assignments to complete at home with family Workshops: physical activity, coffee station makeover Schools: Grade 3–6 curricula Community media: radio, posters	Group counseling (weekly) Individual counseling Incentives Maintenance program	Schools: 40 min MVPA classroom lessons Home: take-home toolkit and activities 3/wk	Group sessions Home: assignments to complete with family, hands-on cultural activities
Process evaluation	High	None	Medium	None	High	Low	Low	Medium
Process evaluation results	Good–excellent	None	Good	None	Good	Fair	Fair	Fair
IFS score	7	7	7	6.5	6.5	6.5	6	6

¹IFS, indigenous food sovereignty; MVPA, moderate to vigorous physical activity; NA, Native American; OPREVENT, Obesity Prevention and Evaluation of InterVention Effectiveness in NaTive North Americans; RCT, randomized controlled trial; T2DM, type 2 diabetes mellitus.

TABLE 4C Study design, process evaluation results, and overall IFS score (low scores 3.5–5.5)¹

Project name	Together on Diabetes	Diabetes Prevention Demo Project (Special Diabetes Program)	Strong in Body and Spirit (Urban DPP)	Healthy Food Labels	Native American Weight Loss Movement
Study design	Pre-post, no comparison 255 at-risk youth, 10–19 y; 225 caretakers	Pre-post, no comparison 3135 adults at risk of diabetes	RCT, by FBG 200 urban women	Choice experiment 115 consumers surveyed	Pre-post, no comparison 32 overweight/obese adults
Intervention strategies	Home visits Collaboration with medical providers Referrals to community resources and events	Counseling: lifestyle coaches deliver intervention 1-to-1 or small groups Goal-based educational curriculum	Counseling: brief 5 session DPP curriculum taught in groups	Food stores: culturally relevant food labels	Counseling: adapted DPP, group sessions
Process evaluation	Medium	None	None	None	Low
Process evaluation results	Good	None	None	None	Fair
IFS score	5.5	3.5	3.5	3	3

¹ DPP, diabetes prevention program; FBG, fasting blood glucose; IFS, indigenous food sovereignty; RCT, randomized controlled trial.

principles, this systematic review found 20 interventions across the United States and Canada that followed IFS principles to varying degrees. The majority of these studies took place in the United States and targeted adults. Overall, interventions that scored high on IFS principles were more likely to assess change in psychosocial constructs, assess outcomes in children/youth (<18 y old), report process evaluation results, target adiposity or dietary outcomes, and demonstrate impact on dietary intake compared with interventions with medium or low scores. Higher-scoring IFS interventions were also more likely to employ an RCT study design, less likely to use individual counseling or individual educational approaches, and have interventions taking place in food stores. Most intervention trials did not assess changes to the food/policy environments or impact on physical activity.

Interventions that scored high on IFS principles were more likely to assess psychosocial impacts and demonstrate impact on diet quality. However, the sustained effects of any of these psychosocial or behavioral changes are unknown; previous research has questioned the long-term effects of changes in psychosocial determinants of behavior relative to environmental or systemic determinants of behaviors (116). The effectiveness of high IFS-scoring interventions on diet quality is consistent with previous research describing the association between traditional food intake and diet quality (117–120). Future interventions should consider engaging with Indigenous food systems at multiple levels such as increasing access to traditional and cultural foods in food access points (food retail venues, etc.) as well as promoting knowledge transmission about traditional food production, preparation, and dietary properties.

Because the interventions that scored highly on IFS principles rarely measured health outcomes (e.g., BMI, weight), we were unable to draw conclusions about IFS principles and overall impact on health. Future research is needed to fully understand how use of IFS principles can play a role in intervention impact. Future IFS interventions should consider soliciting community feedback about measuring and evaluating short-term (food acquisition, dietary intake) health behaviors and long-term health outcomes as part of their design and impact assessment. This is particularly important to advance the evidence base in support of IFS interventions, because these interventions hold such promise in addressing the root causes for Indigenous health inequity. Indigenous peoples continue to face disproportionately high rates of food insecurity and insufficient access to healthy foods, both of which are important drivers of poor diet quality and chronic diseases, like cardiovascular disease and type 2 diabetes. Food sovereignty holds great potential to build community capacity to address healthy food access, as well as food insecurity, while facilitating connection to culture and community. IFS movements have great potential to build community capacity to address health inequities, particularly those related to diet, and future research should consider evaluating the effects of grassroots IFS movements.

Community engagement in intervention design, implementation, and evaluation could lead to more culturally acceptable—and therefore more effective—interventions. Our results suggest that community ownership is associated with the use of other IFS principles because studies that scored high in community ownership also scored higher in traditional knowledge, traditional foods, and impact on policy and environment (IFS principle 4). Community ownership and involvement throughout the research could foster community advocacy for culturally grounded strategies, including the inclusion of traditional

TABLE 5A Food environment/policy assessment methods, health impact, and overall IFS score (high scores 7.5–11)¹

Project name	Healthy Children Strong Families 1	Mega Elicarvigmun (Fish to School)	Healthy Foods North	Iron Deficiency Anemia	THRIVE	Healthy Children Strong Families 2	Medicine Wheel children
Food environment/policy assessment methods	Not assessed	Not assessed	Store stocking data collected	Sales of iron-rich foods	Availability of health foods (modified NEMS-TCS)	Not assessed	Not assessed
Food environment/policy assessment impact	Not assessed	Not assessed	Not reported	Increased sales of iron-rich foods	No impact	Not assessed	Not assessed
Diet/food assessment methods	Three 24HR; block FFQ to assess diet and PA	Single 24HR; nitrogen stable isotope ratio to assess fish and marine mammal intake	Healthy/unhealthy food acquisition questionnaire; FFQ; food preparation methods questionnaire	Questionnaire (unclear)	Brief diet screener, emphasizing FV	Diet screener; nutrition survey Family nutrition environment (Family Nutrition and PA Screening Tool)	Block FFQ to assess diet and PA
Diet/food assessment impact	By treatment: no impact By pre-post (combined): increased child FV servings	Improved intake fish and diet quality	No impact on healthy/unhealthy food acquisition patterns Reduced caloric intake, depromoted food intake and fat intake Increased iron, vitamins A and D Improved healthy food preparation methods	Increased trial of iron-rich foods	No impact	Improved healthy diet pattern for both adults and children Improved adult FV servings No impact on child FV servings No impact on SSB intake Improved family nutrition-related behaviors	Increased vegetable intake
PA methods	TV screen time; accelerometry	Not assessed	2 PA questions	Not assessed	Not assessed	PA questionnaire for adults; child screen time/sleep questionnaire	Not assessed

(Continued)

TABLE 5A (Continued)

Project name	Healthy Children Strong Families 1	Mega Elicarvigmun (Fish to School)	Healthy Foods North	Iron Deficiency Anemia	THRIVE	Healthy Children Strong Families 2	Medicine Wheel children
PA impact	By treatment: no impact By pre-post (combined): decreased TV watching	Not assessed	Not reported	Not assessed	Not assessed	Adults: increased MVPA Child screen time, sleep: no impact	Not assessed
Psychosocial factors assessment methods	Self-efficacy	Traditional food perceptions; enculturation	Self-efficacy, behavioral intentions, and outcome expectations	Survey	Perceived healthier food access	Adults only: Knowledge, Health Behavior Efficacy; cultural involvement scale; stress; cultural identity; readiness to change	Nutrition knowledge
Psychosocial factors impact	By treatment: no impact By pre-post (combined): improved adult self-efficacy	Increased perceptions of benefits of traditional foods and having cultural skills	Improved self-efficacy and intentions	Increased knowledge, self-confidence in preparing infant foods	Perceived improvements in healthier food access (varied by Nation)	Adults only: improved readiness to change, perceived stress, quality of life	Improved nutrition knowledge
Health assessment methods	Adult and child BMI and WC	Not assessed	Height, weight, BMI	Not assessed	Not assessed	BMI	Not assessed
Health impact	By treatment: no impact By pre-post: reduced BMI in obese children only	Not assessed	Not reported	Not assessed	Not assessed	No impact	Not assessed
IFS score	11.5	11	10	10	9	8.5	7.5

¹FV, fruit and vegetable; IFS, indigenous food sovereignty; MVPA, moderate to vigorous physical activity; NEMS-TCS, Nutrition Environment Measures Survey-Tribal Convenience Stores; PA, physical activity; SSB, sugar-sweetened beverage; THRIVE, Tribal Health and Resilience in Vulnerable Environments; WC, waist circumference; 24HR, 24-h dietary recall.

TABLE 5C Food environment/policy assessment methods, health impact, and overall IFS score (low scores 3.5–5.5)¹

Project name	Diabetes Prevention Demo Project (Special Diabetes Program)		Strong in Body and Spirit (Urban DPP)	Healthy Food Labels	Native American Weight Loss Movement
	Together on Diabetes	Diabetes Prevention Demo Project (Special Diabetes Program)			
Food environment/policy assessment methods	Home food availability	Not assessed	Not assessed	Not assessed	Not assessed
Food environment/policy assessment impact	Not reported	Not assessed	Not assessed	Not assessed	Not assessed
Diet/food assessment methods	Adapted block FFQ	Adapted NCI FFQ	Block FFQ + SW Foods	Food choice assessment	Dietary patterns assessed using questions from Behavioral Risk Factor Survey Reduced fast food intake
Diet/food assessment impact	No impact	Healthy food intake increased Unhealthy food intake decreased	Increased vegetable and fruit intake with more exposure	Increased healthy product selection with cultural and generic labels Decreased unhealthy choice selection with cultural label	Reduced fast food intake
PA methods	3-d PA recall	Rapid 9-item assessment of PA	Modifiable PA questionnaire; submaximal bicycle ergometry	Not assessed	PA questionnaire
PA impact	Increased PA	Increased aerobic activity Increased flexibility and strength	No impact on PA Decrease in TV time No impact on ergometry	Not assessed	No impact
Psychosocial factors assessment methods	Quality of life questionnaire; depression screening; knowledge	Not assessed	Not assessed	Not assessed	Perceived stress, depression
Psychosocial factors impact	Improved knowledge Decreased depression Improved quality of life	Not assessed	Not assessed	Not assessed	Not reported
Health assessment methods	Height; weight; point of care HbA1c, WC, blood pressure, hypertension; diabetes screening report	BMI; weight; blood lipids, glucose; blood pressure	Blood glucose; insulin; lipid panels; blood pressure; BMI; hip and waist circumference; bioelectrical impedance	Not assessed	Height; weight; blood pressure; waist circumference; BMI; HbA1c; blood glucose; total cholesterol
Health impact	Reduced mean BMI z-score Reduced hypertension Reduced HbA1c among diabetic youth	Reduced weight, BMI FBG associated with higher healthy food intake and with lower unhealthy food intake	Improved FBG, trends for impact on BMI, weight, blood pressure	Not assessed	Reduced weight Reduced fasting glucose
IFS score	5.5	3.5	3.5	3	3

¹DPP, diabetes prevention program; FBG, fasting blood glucose; FV, fruit and vegetables; HbA1c, glycated hemoglobin; IFS, indigenous food sovereignty; NCI, National Cancer Institute; PA, physical activity; SW, southwest; WC, waist circumference.

TABLE 5B Food environment/policy assessment methods, health impact, and overall IFS score (medium scores 6–7)¹

Project name	Apache Healthy Stores	Medicine Wheel Adults	Navajo Healthy Stores	Earthbox	OPREVENT	Traditions of the Heart	Generations Health	Journey to Native Youth Health
Food environment/policy assessment methods	Sales reports from supermarkets	Not assessed	Healthy food availability	Not assessed	Food store stocking of healthier items	Not assessed	Not assessed	Not assessed
Food environment/policy assessment impact	Increased sales of some targeted foods	Not assessed	No impact	Not assessed	Not reported	Not assessed	Not assessed	Not assessed
Diet/food assessment methods	Healthy food purchasing frequency Healthy food preparation methods Dietary intake (FFQ)	24HR	FFQ; healthy food purchasing; healthy food preparation methods	Self-reported home FV consumption	FFQ; 24HR	Dietary risk assessment questions	24HR	24HR; assisted food record
Diet/food assessment impact	Improved healthy food purchasing Increased frequency of consumption of healthy foods, decreased frequency of consumption of SSBs	No impact	FFQ not reported Improved healthy food purchasing Improved healthy cooking methods	No impact	Decreased soda consumption	Improved "nutrition scores"	No impact	No impact
PA methods	Not assessed	PA diary	Not assessed	Not assessed	Culturally modified IPAQ	PA questions; energy expenditure questions	Accelerometry	Accelerometry; self-reported PA
PA impact	Not assessed	No impact	Not assessed	Not assessed	Increased low to moderate PA levels	Increased PA and energy expenditure (dissertation)	Increased MVPA Increased sleep	No impact
Psychosocial factors assessment methods	Promoted food knowledge, food self-efficacy, and food intentions	Not assessed	Promoted food-related knowledge, self-efficacy, and intentions	FV knowledge; FV preferences	Knowledge, self-efficacy, intentions, social support	Perceived barriers to healthy behaviors	Food knowledge	Nutrition knowledge

(Continued)

TABLE 5B (Continued)

Project name	Apache Healthy Stores	Medicine Wheel Adults	Navajo Healthy Stores	Earthbox	OPREVENT	Traditions of the Heart	Generations Health	Journey to Native Youth Health
Psychosocial factors impact	Improved knowledge No impact on self-efficacy or intentions	Not assessed	Improved healthy food intentions	Improved FV knowledge and preference scores	No impact	Perceived barriers decreased	Improved knowledge	Improved knowledge
Health assessment methods	Not assessed	Weight, BMI, HbA1c, cholesterol, triglycerides, insulin	Weight, height, BMI	Not assessed	BMI, waist, hip circumference	BP, cholesterol, BMI	BMI	Height, weight, BMI
Health impact	Not assessed	No impact	Decreased BMI	Not assessed	No impact on BMI Decreased WC	No impact	Decreased BMI	No impact
IFS score	7	7	7	6.5	6.5	6.5	6	6

¹BP blood pressure; FV, fruit and vegetable; HbA1c, glycated hemoglobin; IFS, indigenous food sovereignty; IPAO, International Physical Activity Questionnaire; MVPA, moderate to vigorous physical activity; OPREVENT, Obesity Prevention and Evaluation of Intervention Effectiveness in NaTive North Americans; PA, physical activity; SSB, sugar-sweetened beverage; WC, waist circumference; 24HR, 24-h dietary recall;

ecological knowledge. This finding is consistent with other literature that suggests that CBPR methodologies are associated with more impactful interventions in Indigenous Nations and communities (121–125). A systematic review to understand the outcomes of CBPR research interventions with American Indian communities found that interventions had improved participatory research outcomes, such as better adherence to CBPR principles, improved knowledge translation, or development of long-term community partnerships (126). This can explain how promoting community ownership can improve traditional knowledge and sustainability of interventions, because the goal of CBPR is to shift power from the researchers to the participating community members. Existing measures, including those offered by Hearod, Wetherill, Salvatore, and Jernigan (36), could be adapted to evaluate the CBPR approaches in IFS interventions (126). CBPR could be a promising approach to improve scores of cultural food knowledge, traditional food intake, and the long-term sustainability of the intervention, and future IFS interventions should include meaningful assessments for adherence to CBPR principles.

Whereas both individual- and community-level interventions used IFS principles, the studies that scored high in IFS principles typically included the whole community/multipronged interventions, with primary settings in schools, home (addressing families), and/or stores. Studies that scored low in IFS principles typically targeted individuals at risk of diabetes or overweight/obesity and focused mostly on imparting disease-prevention knowledge via education in the form of counseling sessions/materials that already existed for other populations. Most low-scoring IFS studies were able to see an impact on health outcomes, physical activity, and diet but had weaker study designs (e.g., pre-post only, with no comparison). A previous systematic review of diabetes prevention programs concluded that lifestyle interventions significantly impacted psychosocial and physiological outcomes (127). However, lifestyle interventions alone are unable to address the systemic barriers to health that Indigenous populations face, including healthy food access, and multilevel interventions are needed to impact the social determinants of health (128, 129). One possible explanation for our results could be intensity of delivery of the intervention, with lower IFS-scoring studies delivered intensively in small groups to highly motivated individuals resulting in greater behavioral impacts, whereas higher IFS-score interventions were more passively delivered at the community level (130). Another explanation for these results is that the majority of the high IFS-scoring studies used a comparison group, whereas the low IFS-scoring studies were more likely to use pre-post assessments in only 1 group.

Lessons learned and recommendations

This review found that high-scoring IFS trials had stronger study designs and were more likely to report impact on diet quality than low-scoring trials; nonetheless, it also identified important gaps in the existing literature from which we draw recommendations below.

First, many of the IFS intervention strategies were focused on individual-level (via individual/group counseling, home/school-based curricula) rather than whole-community strategies. This raises an important question about how to define IFS—can individual-level interventions (via individual/group counseling, home/school-based curricula) be considered IFS interventions if they do not engage the whole community or attempt to change the food system or access to food?

Secondly, it raises questions about how to measure and weight the different IFS guiding principles: for example, should more weight be given to community ownership compared with environmental sustainability? This review found that the environmental sustainability of the intervention (principle 4) was seldom incorporated into the design of interventions or in the discussion of results in the studies reviewed, which is not atypical given the timeline in development and implementation of health policies compared with short trial intervention research (131). A recent review of obesity prevention interventions highlighted common factors for sustaining such programs (132).

Second, the reliance on standard health outcome and behavioral measures might not capture the sphere of influence of studies that implement IFS principles. An important consideration is that IFS guiding principles are intended to address the social and structural determinants of diet-related health inequities in Indigenous communities; however, limiting the assessment of effectiveness of a IFS trial to the standard health and behavioral outcomes can miss out on crucially important potential mediators in the social and structural dimensions of dietary inequities in contemporary food systems. High-scoring IFS study trials could be impacting important underlying determinants of diet behaviors, nutritional status, and diet-related health outcomes that are not captured by standard measures in public health. These could include: people's perceptions of their right to define their own food systems; cultural and language revitalization; and promotion of healthy ecological relations, which can be direct outcomes of interventions that apply IFS guiding principles. Based on the results of our review, we found that few studies measured traditional food intake, traditional or cultural food knowledge, or positive mental health outcomes (e.g., connection to culture, land, or community), all of which can be improved through engagement with each IFS principle. Future interventions should consider designing evaluation measures in direct collaboration with communities, and grassroots food sovereignty movements. Although ultimately the impact must be measured in a public health outcome, the timeline of trial implementation could be too short to see an impact on these standard outcomes within the trial. However, if the use of CBPR and IFS guiding principles has an impact on engagement and advocacy to change food systems in these communities, this could result in an expansion of the sphere of influence of these nutrition intervention trials. To better ascertain this, future research must adapt existing behavioral frameworks that take into consideration potential mediating outcomes in IFS guiding principles that could very well be on the pathway of influence to impact health outcomes eventually.

Limitations and strengths

This review has several limitations. Due to the diversity and complexity of food sovereignty, there is no single agreed definition that can capture the breadth and intricacies of all IFS initiatives. To combat this, we created our own definition, made specifically to characterize 4 IFS principles in the context of research interventions. However, this definition was developed by researchers for the purpose of this systematic review and not informed by community input. We acknowledge the importance of community ownership in IFS, and Indigenous Nations and communities must have a role in identifying and refining the key principles of IFS. Future research could develop a community-informed conceptualization for IFS and its principles. Second, although the environ-

ment principle of IFS that we developed included both environmental and program maintenance aspects of sustainability, the literature on this topic states that these are different concepts (133). Future research could consider these 2 principles of IFS separately so that both of these concepts are considered. Third, IFS is not intended to be a research method and so these principles are not always systematically reported. It is possible that the IFS scores of studies included in this review could vary based on the information gleaned from publications. Four of the trials included were developed in part by 1 of the review's authors (JG) and although we used a relatively objective process, we had a greater understanding of those trials. Future work should look to consistently report on IFS principles across studies, building on the CBPR principles. Fourth, there are limitations to applying such a concept to the scientific literature, because much of the IFS work has been led outside of the academy. Our gray literature and peer-reviewed literature searches revealed that a significant amount of the IFS interventions was not published in peer-reviewed literature and that many initiatives were not conducted in the context of a research intervention, and could have been missed in this review. Fifth, the lack of data on health outcome and process measures of intervention trials impeded systematic assessment of how well each trial was implemented. Future researchers could report on their program's score on our proposed principles in addition to process evaluation dimensions. Lastly, we did not evaluate research bias for authors that designed, implemented, and evaluated their own interventions.

This review is the first, to our knowledge, to attempt to understand how IFS principles have been applied in existing nutrition and food interventions. The definition of IFS we have offered is a novel way to operationalize IFS in research interventions. These principles can be used as a blueprint for future intervention studies that wish to incorporate IFS principles in the planning, implementation, and evaluation of research interventions. Our review of interventions included gray literature and community dissemination reports, which helped to create a more holistic understanding of each intervention. Researchers using IFS should consider planning for community engagement by publishing in both the peer-reviewed and gray literature.

Conclusions

In the last 20 y there has been a surge of interventions promoting IFS, and studies are using it as the foundation for interventions addressing the chronic disease inequities disproportionately affecting Indigenous peoples in the United States and Canada. This review addresses a gap in the literature by operationalizing the core principles of IFS to evaluate research interventions in Indigenous communities. This post hoc assessment found evidence supporting the value of IFS principles in the development, implementation, and evaluation of health interventions for Indigenous communities. Intervention trials that are based on these principles from the outset are greatly needed to support the effectiveness of this approach.

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